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ABSTRACT

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ABSTRACT

The graphics and animation capabilities of computers offer a new dimension in science testing. Instead of presenting verbal situations or questions with accompanying pictures, computers can present simulated actions and events that are the focus of science questions. The purpose of this project was to develop a valid and reliable computer-based test of integrated process skills that employed both graphics and animation to present and pose questions about science phenomena. A pool of items was prepared to assess variable identification, hypothesis formation, operational definition, experimental design, and interpretation of data. Field trials of the computer-based test were conducted with more than 150 students in grades 9 through college level. Students completed the test at computer terminals in about 45 minutes. The results of the field trial show the test to have good reliability. Difficulty and discrimination indices are within the limits expected for tests used to assess criterion-referenced achievement. The computer animated test represents an alternative way to present science phenomena to students for classroom assessment or in research and evaluation studies.

INTRODUCTION

The purpose of testing is to gain reliable and valid information. Test results should reflect true and consistent measures of performance if sound decisions are to be based on them. Problems of test reliability are dealt with by such means as carefully wording items and selecting items with restricted difficulty levels. The validity of test results is a function of several factors. Among these are how well the test items correspond to the performances to be measured and the degree to which item formats allow students to demonstrate what they know.

Science teachers and researchers usually have little trouble with the classic determination of test validity; that is, showing

the correspondence of test objectives and test items. But because of the nature of the material to be tested in science, they may use test formats that disallow true performance or ability to be fairly measured.

Problem solving and applying information are two areas of science learning that offer challenges to valid assessment. The person being tested in these areas must comprehend both a context and actions in order to answer questions correctly. Problem context and actions are typically presented in written form and the burden on the test taker is to convert the printed words into a mental picture of dynamic events. Students with reading comprehension problems or the inability to translate printed words into mental images and actions may be unable to demonstrate their true ability. The result for them is a test that is invalid because it fails to provide a reasonable measure of true performance.

Practical examinations are sometimes used in science testing to overcome the difficulties with printed tests. But space and time constraints may make practical exams an impractical solution. The graphics and animation capabilities of computers offer a new means of addressing the problem. Instead of presenting printed questions or even questions with accompanying pictures, computers can present simulated actions and events that are the focus of science questions.

LITERATURE REVIEW

Assessment of science process or problem solving skills has traditionally been done with paper-and-pencil tests or systematic

observation checklists. Certain tests are linked to specific curricula. For example, McLeod et al. (1975) designed a process skill tests for the SAPA curriculum while Riley (1972) constructed one for SCIS.

Other tests are more generic in nature. Molitor and George (1976), Dillashaw and Okey (1980), Tobin and Capie (1982) and Burns, Wise and Okey (1983) have developed non-curriculum-specific process skill tests aimed primarily toward middle and secondary students.

The literature on using computer simulations to test science process skills is sparse. Berger (1982) used microcomputer simulations to assess students' ability to estimate. Several microcomputer simulations provide students with an opportunity to practice and apply certain skills. These simulations, however, are typically content-bound. For instance, students involved in a titration or fractional distillation simulations would receive practice related to those specific processes. The focus, therefore, tends to be on skills that are not generalizable.

METHODS

Items were selected from previous process skills tests that lent themselves to computer animation. Other items were created to test the following five process skill objectives:

1. To identify variables in an experiment.
2. To identify and state hypotheses.
3. To operationally define variables.
4. To design investigations.
5. To graph and interpret data.

Computer programs portraying events in each of these areas were developed using the Apple Super PILOT authoring languages which has both graphics and animation capability. Apple Super PILOT requires a large amount of disk interaction within the execution of a program, and, the programs and graphics rapidly consume disk memory space. Despite these two problems, the simplicity of the animation and graphics make this language an excellent choice for simulating science phenomena.

Most items present a series of animated scenes that represent a science problem or event. For example, students observe crops being fertilized and growing, or planes flying under different conditions. The illustrations in Figures 1 and 2 give some indication of what students would observe although without the benefit of animation. In this particular problem, graphics and animation are used to show the motion of the sun through the sky and the length of the shadow cast at various times of the day. As these events are depicted the data table showing the time and shadow length is created.

After an event had been depicted students were presented from 1 to 4 questions about it. Figure 3 snows one of the screen displays of a question. If the student wished to review a problem or event before answering questions, it was possible at any time to do so.

Items were designed in a three or four response multiple choice format. Response and demographic data file routines were prepared to store student data. The test was then compiled and edited to fit on one floppy disk. Readability of the test (judged

by analyzing all complete sentences printed on the screen) was found to be at the eighth grade level (Gunning, 1968).

The computer animated test items were then piloted in several college science and science education classrooms with students. More data were collected from high school students in grades 9 through 12. These students were primarily from physical science and biology classes. Data from these two sources were compiled and analyzed to determine how individual options in items functioned, difficulty and discrimination indices, and total test reliability.

The test was analyzed by three specialists in science education. Their instructions were to comment on the validity and objectivity of items, to match the items to one of the five objectives, and to choose the correct answers.

RESULTS

Approximately 150 high school and college students were administered the science process skills test. The students represent a broad range of socio-economic and academic achievement levels. The school district is relatively small in population and draws from a predominantly rural area. The college students were enrolled in a variety of science and science education courses.

Students worked individually at computer terminals and were allowed a normal class period to complete the test. The average time of completion was about 45 minutes.

Overall scores ranged from 5 to 26 correct responses ($\bar{X}$ = 19.42, S.D. = 4.09). On average the students correctly answered about 66% of the items. The reliability (KR-20) was .78

for the test. This index is reasonable considering the number of items in the test. Item difficulties range from .31 to .93 with a mean of .75. The mean discrimination index is .39 with a range of +.23 to +.61.

Mean test scores for the various grade levels ranged from 17.55 to 21.15 (Table 1). The general trend indicated a gradual increase occurring between the high school and the college level students.

Figure 4 provides a summary of the characteristics of the computer animated science process skill test.

SIGNIFICANCE

Assessment of science process skills is an important element in science classes. The situations and events that can be described in written tests or even those with accompanying pictures usually fail to convey dynamic events. Computers provide the possibility of more realistically presenting science phenomena to students in testing situations. Variables can be observed being manipulated or results can be portrayed as they are measured. What results is a more stimulating and accurate portrayal of situations that rely less heavily than conventional assessment procedures on verbal understandings.

Computer animated tests such as the one described here may have special application with students who have difficulty translating words into images. Printed tests may fail to clearly convey events and the scores that result may therefore not provide accurate estimates of the real ability of students.

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The first measurement is made at 8:00 in the morning. The shadow is 20 meters long.

Time of Day	Length of Shadow (m)
8:00	20

Figure 1. A screen display from a computer animated process skill item.

Time of Day	Length of Shadow (m)
8:00	20
10:00	1
12:00	1
2:00	1
4:00	2

Figure 2. A later display in the same process skill problem shown in Figure 1.

What hypothesis was tested?
A. The larger the sun, the longer the shadow.
B. The bigger the house, the longer the shadow.
C. The later the hour of the day, the longer the shadow.

Choose A, B, or C (R to see again)

Time of Day	Length of Shadow (m)
8:00	20
10:00	13
12:00	8
2:00	15
4:00	22

Figure 3. A screen display of test item based on the problem in Figures 1 and 2.

TABLE 1

MEAN PROCESS SKILLS SCORES

GRADE LEVEL	NO. OF STUDENTS	X*	SD
HIGH SCHOOL	66	17.11	4.14
COLLEGE	85	21.15	3.06
TOTAL	151	19.42	4.09

*The maximum score was 26

Process Skills Tested	No. Of Items
Identifying Variables	9
Formulating Hypotheses	6
Operationally Defining	4
Designing Investigations	5
Graphing and Data Interpretation	2
Total Number of Items	26
Response Format	Four Alternative Multiple Choice
Recommended Grade Level	Eighth and above
Time to Complete Test	45-60 minutes
Test Readability (FOG)	Eighth Grade

Discrimination Indices

MEAN	RANGE	
.39	0-.20	(0 Items)
	.21-.40	(15 Items)
	.41-.60	(10 Items)
	.61-.80	(1 Item)

Difficulty Indices

MEAN	RANGE	
.75%	0-.20	(0 Items)
	.21-.40	(1 Item)
	.41-.60	(4 Items)
	.61-.80	(10 Items)
	.81-1.00	(11 Items)

Reliability (KR-20)	.78

Figure 4. Characteristics of the Computer Animated Science Process Skills Test